

IN THE CLAIMS:

1 1.-22. (Cancelled)

1 23. (Currently Amended) A storage system, comprising:

2 a destination storage device configured to store a copy of data from a source
3 storage device;

4 a snapshot storage device configured to store a snapshot version of the data from
5 the source storage device;

6 a process configured to initiate a copy operation of the source storage device,
7 wherein the copy operation is configured to copy each block of the source storage device
8 to the destination storage device, and wherein the copy operation is performed in
9 segments, and wherein each segment is a range of data bytes of the source storage device;

10 the storage system configured to receive a write request to modify a requested
11 range of data bytes of the source storage device while the copy operation of the source
12 storage device is in progress, wherein the write request to modify the requested range of
13 data bytes is a write request range;

14 the storage system further configured to determine that the write request range
15 falls within the range of data bytes of the source storage device being copied while the
16 copy operation is in progress;

17 in response to determining that the write request range falls within the range of
18 data bytes of the source storage device being copied while the copy operation is in
19 progress, the storage system further configured to determine if a particular range of the
20 range of data bytes of the source storage device to be modified by the write request range
21 has already been written to the snapshot storage device;

22 in response to determining that the particular range of the range of data bytes of
23 the source storage device to be modified by the write request range has already been
24 written to the snapshot storage device, the copy operation further configured to copy one
25 | or more bytes of the particular range of the range of data bytes from the snapshot storage

26 device to the destination storage device, the process further configured to write the write
27 request to the source storage device; and

28 in response to determining that the particular range of the range of data bytes of
29 the source storage device to be modified by the write request range has not already been
30 written to the snapshot storage device, the process further configured to copy the
31 particular range of the range of data bytes of the source storage device to the snapshot
32 storage device, the process further configured to write the write request to the source
33 storage device.

1 24. (Previously Presented) The storage system of claim 23, wherein the source storage
2 device is organized in a RAID system.

1 25. (Currently Amended) The storage system of claim 23, wherein the storage system is
2 further configured, in response to determining the write request range falls within the
3 range of data bytes being copied, to hold the write request in a cache and update a
4 snapshot map.

1 26. (Previously Presented) The storage system of claim 23, further comprising a server
2 configured to execute the process.

1 27. (Previously Presented) The storage system of claim 26, wherein the server is
2 operatively connected to a storage area network switch and the server is further
3 configured to communicate with the storage system through the storage area network
4 switch.

1 28. (Previously Presented) The storage system of claim 23, wherein the process is
2 configured to control multiple storage systems.

1 29. (Previously Presented) The storage system of claim 23, wherein the write request
2 comprises a SCSI command.

1 30. (Previously Presented) The storage system of claim 23, wherein the storage system
2 is further configured to send one or more commands by using an in-band protocol.

1 31. (Currently Amended) A method, comprising:

2 starting a copy command from a source storage device to a destination storage
3 device, wherein the copy command copies each block of the source storage device to the
4 destination storage device, the copy command being performed in segments and each
5 segment specifying a range of data bytes of the source storage device;

6 receiving a write request to modify a requested range of data bytes of the source
7 storage device while the copy command is in progress, wherein the write request to
8 modify the requested range of data bytes is a write request range;

9 determining if the write request range falls within the range of data bytes of the
10 source storage device being copied;

11 determining, in response to the write request range falling within the range of data
12 bytes of the source storage device being copied, if a particular range of the range of data
13 bytes of the source storage device to be modified by the write request range has already
14 been written to a snapshot;

15 copying, in response to the particular range of the range of data bytes of the
16 source storage device to be modified by the write request range having already been
17 written to the snapshot, one or more bytes of the particular range of the range of data
18 bytes to the destination storage device from the snapshot; and

19 copying, in response to the particular range of the range of data bytes of the
20 source storage device to be modified by the write request range having not already been
21 written to the snapshot, the particular range of the range of data bytes to the snapshot, and
22 ~~then~~ writing the write request to the source storage device.

1 32. (Currently Amended) The method of claim 31, wherein the source storage device is
2 organized in a RAID system.

- 1 33. (Previously Presented) The method of claim 31, further comprising:
2 in response to determining the write request range falls within the range of data
3 bytes of the source storage device being copied, holding the write request command in a
4 cache, and updating a snapshot map associated with the snapshot.
- 1 34. (Previously Presented) The method of claim 31, further comprising:
2 executing the copy command by a replication manager.
- 1 35. (Previously Presented) The method of claim 31, further comprising:
2 connecting a server to a storage area network switch and communicating with a
3 storage system through the storage area network switch to execute the copy command.
- 1 36. (Previously Presented) The method of claim 31, further comprising:
2 controlling multiple storage device controllers by a replication manager.
- 1 37. (Previously Presented) The method of claim 31, wherein the write request comprises
2 a SCSI command.
- 1 38. (Previously Presented) The method of claim 31, further comprising:
2 sending a storage system command using one of an in-band protocol or an out-of-
3 band protocol.
- 1 39. (Currently Amended) A computer-implemented method, comprising:
2 starting a copy operation by copying data from a source storage device to a
3 destination storage device, the copy operation being performed in segments, and each
4 segment having a range of data bytes of the source storage device;
5 receiving a write request to modify a requested range of data bytes of the source
6 storage device while the copy operation is in progress, wherein the write request to
7 modify the requested range of data bytes is a write request range;

8 determining if the write request range falls within the range of data bytes of the
9 source storage device being copied;

10 determining, in response to the write request range being in the range of data
11 bytes of the source storage device being copied, if a particular range of the range of data
12 bytes of the source storage device to be modified by the write request range has been
13 written to a snapshot;

14 copying, in response to the range of data bytes of the source storage device to be
15 modified by the write request range having been written to the snapshot, one or more
16 bytes of the particular range of data bytes to the destination storage device from the
17 snapshot storage; and

18 copying, in response to the range of data bytes of the source storage device to be
19 modified by the write request range having not been written to the snapshot, the
20 particular range of the range of data bytes of the source storage device to the snapshot,
21 and then writing the write request to the source storage device.

1 40. (Currently Amended) A system, comprising:

2 a destination storage device configured to store a copy from a source storage
3 device;

4 a snapshot storage device configured to store a snapshot version of the data from
5 the source storage device;

6 a process configured to initiate a copy operation of the source storage device
7 wherein the copy operation comprises copying each block of the source storage device to
8 the destination storage device, the copy operation being performed in segments, and each
9 segment having a range of data bytes of the source storage device;

10 the system configured to receive a write request to modify a requested range of
11 data bytes of the source storage device while the copy operation is in progress, wherein
12 the write request to modify the requested range of data bytes is a write request range;

13 the system further configured to determine that the write request range falls within
14 the range of data bytes of the source storage device being copied;

15 in response to determining that the write request range falls within the range of
16 bytes of the source storage device being copied, the system further configured to
17 determine if a particular range of the range of data bytes of the source storage device to
18 be modified by the write request range has been written to a snapshot of the snapshot
19 storage device;

20 in response to determining that the particular range of the range of data bytes of
21 the source storage device to be modified by the write request range has been written to
22 the snapshot, the process further configured to copy one or more bytes of the particular
23 range of the range of data bytes to the destination storage device from the snapshot
24 storage device; and

25 in response to determining that the particular range of the range of data bytes of
26 the source storage device to be modified by the write request range has not been written
27 to the snapshot, the process further configured to copy the particular range of the range of
28 data bytes of the source storage device to the snapshot storage device, the process further
29 configured to write the write request to the source storage device.

1 41. (Previously Presented) The system of claim 40, wherein the process is executed on a
2 file server and is further configured to control the source storage device and one or more
3 other storage devices.

1 42. (Previously Presented) The system of claim 40, further comprising a list of source
2 storage device data blocks to be copied, wherein the list is configured to be reordered.

1 43. (Previously Presented) The system of claim 42, wherein the list of source storage
2 device data blocks to be copied is buffered while the system awaits further copy
3 commands.

1 44. (Previously Presented) The system of claim 40, wherein the process is further
2 configured to insert control data before and after a source storage device data block is
3 copied.

1 45. (Previously Presented) The system of claim 40, wherein the process is further
2 configured to specify a block size so that the storage system writes one or more fixed-size
3 blocks.

1 46. (Currently Amended) A method, comprising:

2 receiving a write request while a copy operation is in progress wherein the copy
3 operation comprises copying each block of ~~the a~~ source to ~~the a~~ destination, the copy
4 operation being performed in segments, and each segment has a range of data bytes of the
5 source, the write request to modify a requested range of data bytes in a source storage
6 device, wherein the write request to modify the requested range of data bytes is a write
7 request range;

8 determining if the write request range being copied falls within a particular range
9 of the range of data bytes of the source storage device to be modified by the write request
10 range;

11 determining that the particular range of the range of data bytes of the source
12 storage device to be modified by the write request range has not been written to a
13 snapshot;

14 in response to determining that the particular range of the range of data bytes of
15 the source storage device to be modified by the write request range has not been written
16 to the snapshot, copying the particular range of the range of data bytes of the source
17 storage device to be modified by the write request range to the snapshot before modifying
18 the particular range of the range of data bytes of the source storage device;

19 in response to determining that the particular range of the range of data bytes of
20 the source storage device to be modified by the write request range has been written to
21 the snapshot, copying one or more bytes of the particular range of the range of data bytes
22 to the destination from the snapshot;

23 updating a snapshot map, wherein the snapshot map indicates which blocks of the
24 range of data bytes are located in the snapshot; and

25 | modifying the particular range of the range of data bytes of data in the source
26 | storage device from the write request.

1 47. (Previously Presented) The storage system of claim 23, further comprising:
2 a first in first out queue configured to buffer the write request in response to
3 determining that the particular range of the range of data bytes of the source storage
4 device to be modified by the write request range has not been written to the snapshot.

1 48. (Previously Presented) The method of claim 31, further comprising:
2 placing the write request in a first in first out queue in response to determining
3 that the particular range of the range of data bytes of the source storage device to be
4 modified by the write request range has not been written to the snapshot.

1 49. (Currently Amended) A computer-readable storage media containing executable
2 program instructions executed by a processor, comprising:
3 program instructions that receive at a source storage device a write request issued
4 from a storage system, the write request specifying a first range of data bytes of the
5 source storage device, the write request being received while the source storage device is
6 being copied to a destination storage device;
7 in response to receiving the write request, program instructions that hold the write
8 request in a cache;
9 program instructions that check if the first range overlaps with a particular range
10 of the range of data bytes of the source storage device to be modified by the write request
11 that is being copied to the destination storage device;
12 program instructions that determine if the particular range of the range of data
13 bytes of the source storage device to be modified by the write request has already been
14 written to a snapshot storage device;
15 | in response to the first range overlapping with the particular range of the range of
16 | data bytes of the source storage device to be modified by the write request already having
17 | been written to the snapshot storage device, program instructions that copy one or more

18 bytes of the particular range of the range of data bytes from the snapshot storage device
19 to the destination device;
20 program instructions that update a snapshot map; and
21 program instructions that allow the write request to write to the source storage
22 device.

1 50. (Currently Amended) A method for making a copy of data in a database,
2 comprising:
3 starting a copying operation of a source storage device to a destination storage
4 device, wherein the copy operation is performed in segments and each segment is a range
5 of data bytes of the source storage device, the copy operation started at a begin time;
6 maintaining a snapshot volume that includes each block of the source storage
7 device that has a write request directed to that block during ~~the~~ a course of the copy
8 operation;
9 receiving a write request directed to a particular range of the range of data bytes
10 to be modified by the write request range that currently is being copied to the destination
11 storage device;
12 in response to determining that the particular range of the range of data bytes to
13 be modified by the write request range has been copied to the snapshot volume,
14 continuing the copy operation to the destination storage device using one or more bytes
15 of the particular range of the ~~range~~ range of data bytes from the snapshot;
16 in response to determining that the particular range of the range of data bytes to
17 be modified by the write request range has not been copied to the snapshot volume,
18 holding the write request until the particular range of the range of data bytes to be
19 modified by the write request range is copied to the snapshot volume;
20 after completion of writing the particular range of the range of data bytes to be
21 modified by the write request range to the snapshot volume, executing the write request
22 on the source storage device to update the source storage device; and

23 copying the snapshot volume to the destination storage device, wherein the copied
24 snapshot volume maintains a copy of a data on the destination storage device as the data
25 existed on the source storage device at the begin time.

1 51. (Currently Amended) A system to make a copy of data in a database, comprising:
2 a process executing on a processor of the system configured to initiate a copy
3 operation of a source storage device to a destination storage device, wherein the copy
4 operation is performed in segments and each segment is a range of data bytes of the
5 source storage device, the copy operation started at a begin time;
6 the system configured to maintain a snapshot volume that includes each block of
7 the source storage device that has a write request directed to that block during ~~the a~~
8 course of the copy operation;
9 the system is further configured to receive a write request directed to the range of
10 data bytes currently being copied to the destination storage device;
11 in response to determining that a particular range of the range of data bytes to be
12 modified by the write request range has been copied to the snapshot volume, the system
13 further configured to continue the copy operation to the destination storage device using
14 one or more bytes of the particular range of data bytes from the snapshot;
15 in response to determining that a particular range of the range of data bytes to be
16 modified by the write request range has not been copied to the snapshot volume, the
17 system ~~is~~ further configured to hold the write request until the particular range of the
18 range of data bytes to be modified by the write request range are copied to the snapshot
19 volume;
20 after completion of writing the particular range of the range of data bytes to be
21 modified by the write request range to the snapshot volume, the system is further
22 configured to execute the write request on the source storage device to update the source;
23 and
24 the system ~~is~~ further configured to copy the snapshot volume to the destination
25 storage device, wherein the copied snapshot volume is configured to maintain a copy of a

26 data on the destination storage device as the data existed on the source storage device at
27 the begin time.

1 52. (Currently Amended) A computer-readable storage media containing executable
2 program instructions executed by a processor, comprising:

3 program instructions that start a copying operation of a source storage device to a
4 destination storage device, wherein the copy operation is performed in segments and each
5 segment is a range of data bytes of the source storage device, the copy operation started
6 at a begin time;

7 program instructions that maintain a snapshot volume that includes each block of
8 the source storage device that has a write request directed to that block during ~~the a~~
9 course of the copy operation;

10 program instructions that receive a write request directed to a particular range of
11 the range of data bytes to be modified by the write request range that currently is being
12 copied to the destination storage device;

13 in response to determining that the particular range of the range of data bytes to
14 be modified by the write request range has been copied to the snapshot volume, program
15 instructions that continue the copy operation to the destination storage device using one
16 or more bytes of the particular range of the range of data bytes from the snapshot;

17 in response to determining that the particular range of the range of data bytes to
18 be modified by the write request range has not been copied to the snapshot volume,
19 program instructions that hold the write request until the particular range of the range of
20 data bytes to be modified by the write request range are copied to the snapshot volume;

21 program instructions that, after completion of writing the particular range of the
22 range of data bytes to be modified by the write request range to the snapshot volume,
23 execute the write request on the source storage device to update the source storage
24 device; and

25 program instructions that copy the snapshot volume to the destination storage
26 device, wherein the copied snapshot volume maintains a copy of a data on the destination
27 storage device as the data existed on the source storage device at the begin time.

1 53. (Previously Presented) The storage system of claim 23, wherein the storage system
2 is further configured to send one or more commands by using an out-of-band protocol.

1 54. (Currently Amended) The method of claim 31, further comprising:
2 in response to determining that the write request range does not fall within the
3 particular range of the range of data bytes of the source storage device being copied,
4 determining if the write request range is directed to a next particular range of the
5 range of data bytes that has not yet been written to the snapshot; and
6 in response to determining that the write request range is directed to the next
7 particular range of the range of data bytes that has not yet been written to the
8 | snapshot, copying the next particular range of the range of data bytes not yet written
9 to the snapshot.